Forage Handling, Preservation and Storage

The Survival of Silage Inoculant Lactic Acid Bacteria in Rumen Fluid
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Introduction

Inoculants containing principally lactic acid bacteria (LAB) are used as silage additives in order to improve preservation efficiency. In recent studies, silage inoculation has increased milk production or rate of gain in approximately half the animal trials. However, the cause of improved animal performance is unclear. Some results suggest a possible probiotic effect from inoculant LAB, the mechanism of which is also unclear. One hypothesis is that specific LAB strains interact with rumen microorganisms to enhance rumen functionality and animal performance. For this to occur, LAB ingested by the animals would have to survive in rumen fluid in order to affect rumen microflora. The purpose of the current study was to assess the survival of selected LAB from commercial silage inoculants in rumen fluid.

Methods

Rumen fluid (RF) was collected for each experiment from two fistulated Holstein cows fed on total mixed ration containing 30% alfalfa silage, 30% corn silage, 10% solvent soybean meal, 30% ground shell corn and supplemental vitamins and minerals. The combined RF from the two cows was strained (SRF) through four layers of cheesecloth. The SRF was subdivided into sterile Erlenmeyer flasks, each of which was inoculated with a commercial LAB silage inoculant at 10^7 cfu ml^{-1}. Rumen fluid with no LAB inoculant served as a control. Each flask was further subdivided, and to one half was added sterile 50% (w/v) glucose solution to a final concentration of 5 g l^{-1}. The various treatments were added to sterile serum bottles that were flushed with CO_2 before sealing. The bottles were incubated at 39^0C without shaking. At 6, 12, 24, 48 and 72 h after inoculation two bottles from each treatment were sampled for analysis. The rumen fluid was analyzed for pH and LAB. The 48 and 72 h samples were also analyzed for lactic acid and volatile fatty acids.

Results and Discussion

The inoculants were tested in two experiments: inoculants 1 to 5 in experiment 1 and 6 to 12 in experiment 2. The fresh SRF prior to inoculation contained LAB counts of 6.2 and 5.7 $\log_{10}$ cfu ml^{-1} and pH values of 5.70 and 5.57 for experiments 1 and 2, respectively. Thus, inoculation provided approximately a 10-fold increase in LAB numbers over background levels in the control treatment.

Fig. 1A shows the change in pH of selected treatments during incubation of SRF in Experiment 1. In both experiments, glucose supplementation resulted in lower pH values throughout the incubation period, as compared with no glucose addition. A striking observation is that many of the inoculated

treatments had higher pH values than the respective uninoculated control during the incubation period. Without glucose, 8 of 12 inoculants resembled strain 2 (Fig. 1A), providing a significantly higher pH than the uninoculated treatment at 24 to 72 h. With glucose, 8 of 12 inoculants (not necessarily the same strains) had higher pH values at 24 and 48 h than the control, like strain 2.

Fig. 1B shows the change in LAB of selected treatments with time in the SRF. In the inoculated treatments without glucose addition, there was generally a decrease in LAB counts relative to the inoculation rate (10^7 cfu ml^{-1}) especially in the initial 12 to 24 hours, followed by a recovery at 48 h to near initial values. With glucose, the LAB counts in inoculated treatments declined less in the first 12 h and generally were higher at a given time point than those in corresponding vials without glucose. LAB numbers in the control samples increased, without and with glucose, for the first 24 h and decreased later in each experiment.

Some shifts in fermentation products were observed, but the results were not consistent across the two experiments. In Experiment 1, propionate and butyrate were significantly affected by inoculation, decreasing and increasing, respectively, relative to the controls. In Experiment 2, in which volatile fatty acid (VFA) levels in the control samples were high, inoculation suppressed VFA formation. Inoculation in Experiment 2 increased the molar fraction of propionate and produced a trend for reduced acetate.

Conclusions

The LAB tested were able to survive and in many cases grow in strained rumen fluid. As expected, glucose addition markedly enhanced the survival of the inoculant LAB in the rumen fluid, suggesting that silage inoculant LAB strains can compete effectively with rumen microflora in the presence of exogenous glucose. Many of the LAB inoculant strains were able to buffer pH and shift VFA profiles. This suggests that at least some inoculant LAB strains could have an effect on rumen microbial fermentation. However, more research is needed to determine if this direct effect is the principal means by which silage inoculants improve animal performance.

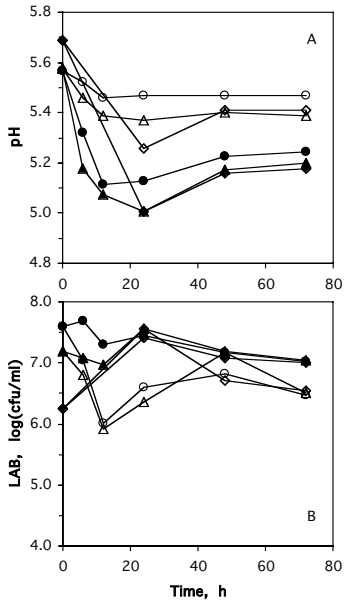

Figure 1. Changes in pH and LAB counts in strained rumen fluid during incubation with inoculants in Experiment 1. ◆Uninoculated; ▲ Inoculant 1; ● Inoculant 2. Open symbols, without glucose; solid symbols, with glucose.

Density and Losses in Pressed Bag Silos

R.E. Muck and B.J. Holmes

Introduction

The pressed bag silo is an increasingly popular method of making silage. It is relatively inexpensive. Storage size varies with the quantity of forage harvested. For farms with expanding herd size, silo capacity can be added with little capital cost. Small diameter bags allow small farms to consider making silage rather than hay. Finally, bag silos make it easy for farmers to inventory and manage silage, e.g., reserving high quality silage for the best animals. While bag silos have been used for more than 20 years, relatively little research has been published on the performance of these silos. Thus, the objectives of this study were to measure densities and losses in bag silos and to determine potential factors affecting both.

Methods

All bag silos made at three University of Wisconsin research farms [Arlington (Arl), Prairie du Sac (PDS), West Madison (WM)] during 2000 and 2001 were monitored. Most of the silages were either alfalfa or whole-plant corn. The primary bagging machines were a 2.4 m Ag-Bag G6000 (AB) at PDS and a 2.7 m Kelly-Ryan DLX (KR) shared between Arl and WM. Occasionally Arl rented a 2.7 m Ag-Bag machine. All loads of forage entering the bags were weighed. While each load was emptied into a bag, a grab sample was taken consisting of a composite of several handfuls. After each load was pressed into the bag, the side of the bag was marked to indicate the distance filled by the load. The load samples were analyzed for moisture content and particle size distribution. At emptying, the weight of all silage removed from a bag was recorded. Any spoiled silage not fed was weighed and specifically identified as such on the emptying log. A grab sample from the face of each silo was taken periodically, one per filling load. Spoiled silage was sampled separately. Samples from emptying were analyzed for moisture, pH and fermentation products. Average densities for the bags were calculated based on weight ensiled, overall length and nominal diameter. Core samples were taken at the face of several bags during emptying to measure density variation across the face.

Results and Discussion

Over the two years, 47 bag silos were made at the three farms. All were filled rapidly with no longer than two days from the start of filling until sealing. The dry matter (DM) contents of the hay crop silages were generally drier than recommended (30 to 40% DM) whereas the corn silages were largely within that range.

Dry matter densities for the 47 bag silos are shown in Figs. 1 and 2. Dry matter density increased with DM content in hay crop silages on average 3.0 kg/m^3-% DM. The effects of DM content on density in corn silage varied by bagging machine. Density increased with DM content with the AB machine whereas density was unaffected by DM with the KR. The DM densities in corn silage were generally lower than those in hay crop silages with the KR. Densities with the AB were generally higher in corn silage, particularly corn silage without kernel processing. Operators affected density. The KR was used at two farms, and one farm consistently averaged higher densities than the other. Densities in hay crop silage with the AB machine at PDS improved the second year after the crew received advice from the manufacturer.

Core samples taken at the face of bags during emptying found considerable variation in density. The outer 30 cm on the top and upper sides had densities on average 40% of those in the center and lower portions, suggesting the need for higher feed out rates than might be anticipated for similar average densities in bunker silos.

Dry matter losses have been calculated on the first year's bags. Average DM losses were 9.5% invisible plus uncollected losses and 6.9% spoilage losses for a total of 16.4% loss. Of the 24 bags, six had severe total losses of more than 25%. The high losses were attributed to either issues of plastic integrity or overly dry silage (>40% DM) being fed out under warm weather. Removing those six bags from the average reduced spoilage and total losses to 2.7% and 11.4%, respectively. Spoilage was primarily at the ends in the remaining bags. Invisible plus uncollected losses did not appear to be affected by feedout temperature or storage time. These losses were elevated at low DM contents and tended to be higher at low feedout rates.

Conclusions

The DM densities in bag silos varied by machine, operator, DM content and crop. The densities observed in this study were somewhat lower than, but within the range of, those observed for bunker silos. However, the wide variation in density across the face plus occasional heating problems in bags fed out at 20 cm/d suggest a minimum feedout rate of 30 cm/d. Our results indicate that the 30 to 40% DM content recommendation for ensiling in bags does result in the lowest losses. In that range, total losses from bag silos can be similar to losses from tower silos. Substantial spoilage losses can occur if bags are not routinely monitored for holes and patched or if overly dry silage (>40% DM) is fed out under warm weather.

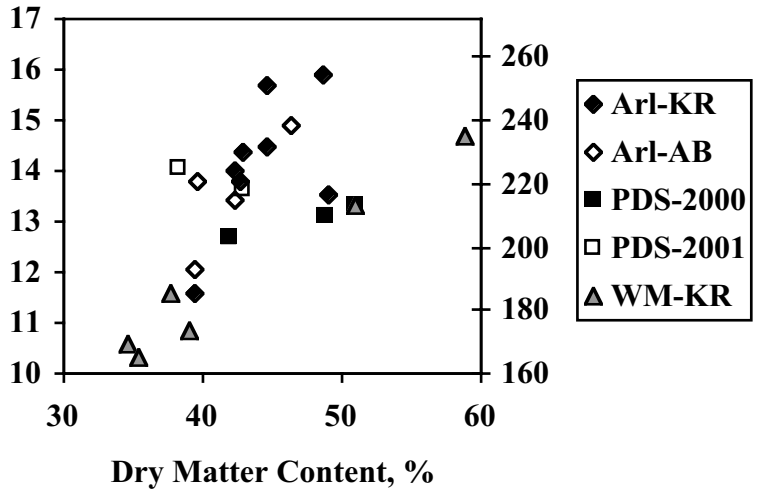

Figure 1. Average dry matter densities (left, lbs/ft^3; right, kg/m^3) in hay crop silages.

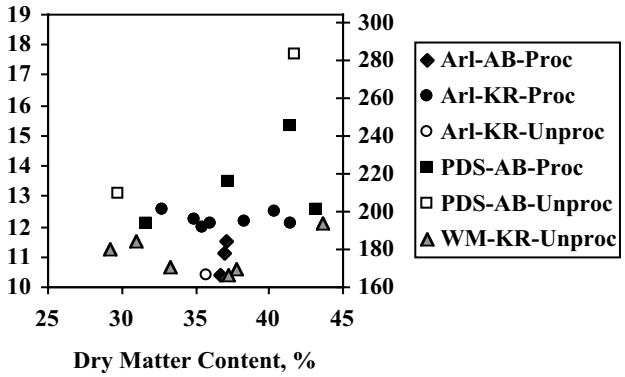

Figure 2. Average dry matter densities (lbs/ft^3, left; kg/m^3, right) in corn silages. Proc - kernel processing; Unproc - not processed.

Factors Influencing Density in Bunker Silos
R.E. Muck, P. Savoie and B.J. Holmes

Introduction

A high silage density is desirable to increase silo storage capacity and reduce silage porosity, thereby reducing oxidation loss and preserving a high feed value. Previous research has shown that dry matter (DM) density in bunker silos is very variable, between 106 and 434 kg/m^3 from a survey of 168 commercial bunker silos in Wisconsin. That study indicated that density was correlated with packing tractor weight, packing time per as fed tonne, layer thickness, DM content, and silage height. However, such correlations between density and a packing practice do not necessarily mean that a particular practice is important for obtaining a high density. A pilot-scale compactor was built and used to test the significance of these packing factors on density.

Methods

A platen press with a 0.58 m long by 0.48 m wide footprint was used to compress chopped forage (alfalfa, grass, whole-plant corn) in a rectangular chamber. The platen was pressed against the forage with a hydraulic cylinder (64 mm dia.), achieving pressures of 20 to 80 kPa. Depending on the trial, layers of chopped forage were laid in non-compacted thicknesses of 0.15, 0.30 or 0.46 m. After each layer was placed in the chamber, the platen was lowered at the designated pressure for times varying between 1 and 10 s. After compaction, the forage was left to relax about 1 min before the next non-compacted layer was added. The compressed and relaxed heights as well as height after adding a new layer were measured to estimate the compressed, relaxed and pre-compression densities, respectively.

For a given trial, an equivalent of six 0.30 m layers were placed in the chamber at a minimum. On a given day, a series of compaction trials were performed by varying only one of the following variables: pressure, layer thickness or time of compaction. The standard conditions were 40 kPa, 0.30 m layer thickness and 5 s hold time. All the forage for a given day was chopped with a commercial forage harvester, usually set to 10 mm theoretical length of cut, and blown in the back of a pickup

truck for transport to the press. Moisture content of the forage was measured to calculate DM density but was not controlled from one experiment to the next.

Results and Discussion

A total of 48 trials were performed (17 alfalfa, 3 alfalfa-grass mixture, 3 grass, 25 corn). Three sets of trials with corn are shown in Figs. 1 to 3. Pressure (Fig. 1) increased density, and the magnitude of the differences between pressures increased with each succeeding layer. Longer times of compaction per layer (Fig. 2) also increased density, but the effect was not linear. Increasing compaction time per layer from 1 to 2 s substantially increased density, but longer compaction times (5, 10 s) produced only small further increases in density. On several sets of trials (data not shown), each layer was compressed for 6 s, but the 6 s was achieved in one of three manners: one 6-s compression, two 3-s compressions or three 2-s compressions. How the 6 s of compression per layer was achieved had no consistent effect on density. Layer thickness (Fig. 3) had a smaller effect on density than expected from the bunker silo density survey.

For each trial, the increase in relaxed density with each succeeding layer fit a logarithmic equation well:

$$r = a + b \ln N$$

where **r** is the dry matter density (kg DM/m^3), **a** is a parameter reflecting the density of the first or uppermost compacted layer, **b** is a parameter reflecting the increase in density with an increasing number of layers, and **N** is the number of 30-cm layers. In hay crop forages, **b** was significantly affected by DM content and pressure whereas **a** was also affected by crop and chop length as determined by stepwise regression. Layer thickness and time were not significant. In corn, time and pressure affected both **a** and **b**. Additionally, processing affected **a** whereas layer thickness affected **b**.

Conclusions

The pilot-scale compactor results indicate that pressure, packing time and layer thickness are important in determining density, but the magnitudes of contributions of these packing factors to density are somewhat different than suggested by our earlier survey of bunker silos. From the pilot-scale trials, pressure appears more important than the other two. However, field-scale trials will be important to confirm the results obtained in the pilot-scale research.

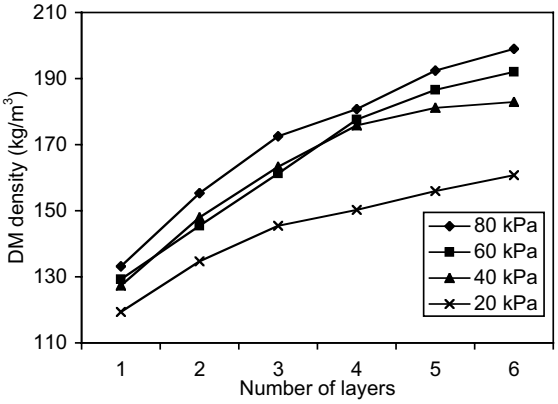

Figure 1. Effect of pressure on relaxed DM densities in corn silage.

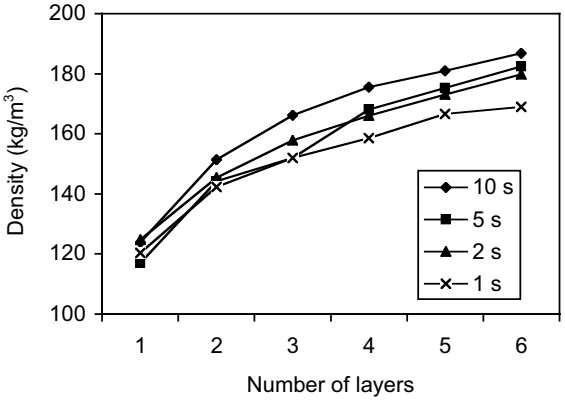

Figure 2. Effect of compaction time per layer on relaxed DM densities in corn silage.

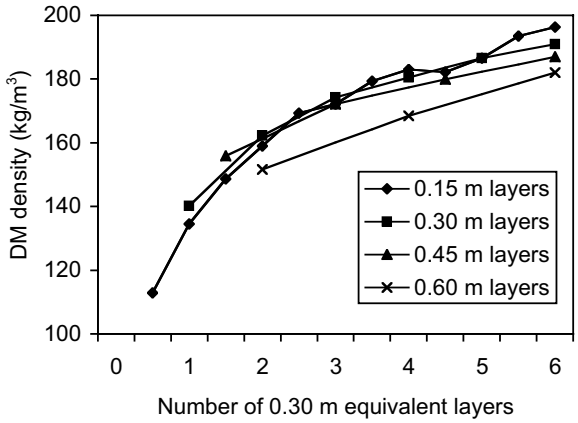

Figure 3. Effect of initial layer thickness on relaxed DM densities in corn silage.